Seismic Retrofit Design for a Network Arch Bridge with Energy Absorbing Devices

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Summary

This article describes performance-based seismic retrofit design for a network arch bridge. Three-dimensional non-linear dynamic time history analyses were carried out considering site-specific earthquake ground motions. The damage control design concept was employed to achieve a rational seismic retrofit with seismic response-control. Optimal design using hysteretic shear panel dampers with low yield strength steel, effective for absorbing the seismic energy, is discussed from dynamic analyses.

Keywords: Performance-based seismic retrofit design, Network arch bridge, Damage control, Shear panel damper, and Non-linear dynamic time history analysis

1. Introduction

The 1995 Hyogo-ken Nanbu earthquake (widely known as the Kobe earthquake) caused severe damage to many bridge structures along the Kobe route as well as the Wangan route of the Hanshin Expressway. After this devastating earthquake, seismic retrofit projects for existing bridge structures have been accelerated in Japan. In the Hanshin Expressway, most of the middle- or small-scale bridge structures have been strengthened seismically to resist a similar intensity of ground motions as the Hyogo-ken Nanbu earthquake, or large-scale (Level 2) earthquake ground motions [1]. Concrete piers have been strengthened by steel plates or concrete linings, and steel piers have been reinforced with filled concrete and steel ribs. Bridge restrainer systems have been applied to general (middle- or small-scale) bridge superstructures. Although seismic retrofits for general bridges have been implemented with a set priority, seismic retrofits for long-span or special bridge types are lagging behind because a more advanced analysis technique is needed to take into account the complicated mechanical characteristics and effects of boundary conditions on such bridges. It is also because there is concern that seismic retrofit costs are high and the application of the same methods of general bridges is not suitable for long-span or special type bridges. Despite this, the consequences of long-span bridges being damaged are higher, and the influence of time and cost for recovery need to be considered.

This article describes performance-based seismic retrofit design for a network arch bridge with a main span of 160 m. Three-dimensional non-linear dynamic time history analyses were carried out considering two types of scenario Level 2 earthquake ground motions. The analysis results revealed excesses of allowable strains on steel piers and pier anchors and allowable relative displacements between piers and superstructures. The damage control design concept was employed to achieve rational seismic retrofit with seismic response-control. Optimal design using hysteretic shear panel dampers with low yield strength steel, effective for absorbing the seismic energy, is discussed from dynamic analyses.

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